UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

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MEMORANDUM

SUBJECT: EFED Reregistration Document for **Thiabendazole**.

TO: Beth Edwards, Chemical Review Manager
Special Review and Reregistration Division (7505C)

FROM: Thuy L. Nguyen, Chemist
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This memo summarizes the EFED Environmental Risk Assessment (science chapter) for the Thiabendazole Reregistration Eligibility Decision document. It includes recommendations for labeling and identifies gaps and uncertainties resulting from outstanding data requirements.

Although thiabendazole is highly toxic to fish and aquatic invertebrates and is very persistent in soils, EFED believes that there will be minimal potential risk to terrestrial animals or aquatic animals resulting from the use of this fungicide to control diseases in mushrooms and wheat. In addition, EFED does not expect the parent thiabendazole and its degradates to enter the drinking water resources at any significant level.

DATA GAPS

The environmental fate and toxicity database for thiabendazole is largely complete and adequate for risk assessment. Note that the field studies submitted by the registrant only provide acceptable information on the dissipation of the flowable concentrate formulation of thiabendazole. Technically, to satisfy the terrestrial field dissipation data requirement, acceptable data are needed for each formulation type (flowable, wettable and dust) at two typical use sites.

However, based on the use conditions and the high sorption affinities of thiabendazole, EFED believes that the formulation type will not significantly affect the dissipation pattern of this chemical in the field, and the submitted data are sufficient to satisfy the above mentioned data requirement.

This report does not include the uses of thiabendazole hypophosphite salt (Chemical 060102). This mineral acid salt of Thiabendazole is formed *in situ* during the formation of the end use product by the addition of hypophosphorous acid to thiabendazole. The salt is used to control anthracnose in sycamore trees, Dutch elm disease in elm trees, and also to control mold and mildew in adhesives, paint, textiles, and paper products. The salt is manufactured by Merck and distributed by Novartis for tree use, and Calgon for mold and mildew control. The database for thiabendazole hypophosphite salt is incomplete, with most studies either in a no decision status, inapplicable or waived status. Outstanding studies for this chemical include: Aerobic Soil Metabolism (162-1), Anaerobic Soil Metabolism (162-2), Terrestrial Field Dissipation (164-1) and Bioaccumulation in fish (165-4).

LABELING RECOMMENDATIONS

EFED recommends that the labels for thiabendazole products include the following:

Environmental Hazards Statements: This product is toxic to fish and aquatic invertebrates. Do not apply directly to water or to areas where water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwater or rinsate.

ENVIRONMENTAL RISK BRANCH III TEAM FOR THIABENDAZOLE

Thuy Nguyen, Chemist	Environmental Fate
William Erickson, Biologist	Ecological Effects
Henry Nelson, Ph.D.	Peer Review

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ENVIRONMENTAL RISK ASSESSMENT
THIABENDAZOLE

A. USE CHARACTERIZATION

Thiabendazole is a systemic fungicide currently registered for (1) direct injection into trees, (2) postharvest application to a wide variety of terrestrial food crops (mostly potatoes, citrus and pome fruits) and non-terrestrial food crops (ornamentals, turf and tobacco), and (3) preharvest application as seed treatment. For this reregistration, the only supported preharvest uses are indoor application to mushrooms and indoor seed treatment for wheat.

During the SMART meeting of August 10, 1998, Novartis stated that thiabendazole is applied as a seed treatment to approximately 3-5% of the 80 million acres of U.S. wheat crop, mainly in North Dakota, Montana, Minnesota, Ohio, and Idaho. The maximum rate of application is registered at 3.6 oz ai/100 lb of seed. This corresponds to 0.2 lb. ai/A in the field with the assumption that 90 lbs of treated seed will be planted in one acre. However, thiabendazole is typically applied at a much lower rate (0.25 oz ai/100 lb of seed, or 0.014 lb. ai/A), in combination with other pesticides also registered for seed treatment, such as manels, captan or thiram.

Single active ingredient formulations of thiabendazole include wettable powder, flowable concentrate, and dust. It is manufactured by Merck & Co. and used in various formulations by Novartis, Uniroyal, Merck, Elf Atochem, Wilbur Ellis, Brogdex, J.R. Simplot, Gustafson, FMC, Zeneca Ag, Calgon, Simplot, Fresh Mark, Platte Chemical, Agri Chem, EnviroChem, Guardsman Products, Ecoscience Produce, and Campbell's Fresh.

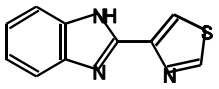
Application information for the proposed new sites is tabulated below.

Use Site	***Single Appl. Rate***	***Number of Application***	***Application time / Application interval (days)***	***Method of Application***
Mushrooms	10 oz ai/1000ft^2	6	During growth	Spray
Wheat (seed treatment)	0.25 -3.6 oz ai/100 lbs*	1	Pre plant	Seed treater
Potato (indoor)	20 oz ai/100 gals	1 - 3	Post harvest / 30 days	Spray
Citrus (indoor)	40 - 68 oz ai/100 gals	1	Post harvest	Spray or Brush
Pome fruit (indoor)	8 oz ai/100 gals	1 - 2	Post harvest	Dip, Flood or Spray
Banana (indoor)	3 - 6 oz ai/100 gals	1	Post harvest	Dip, Cascade or Spray
Carrots	20 oz ai/100 gals	1	Post harvest	Dip
Ornamentals	14 oz ai/100 gals	1	Post harvest	Dip
Tobacco	0.96 oz ai/100 lbs	1	Post harvest	Steam

* 90 lbs of seed planted per acre

1. CHEMICAL:

Common name: Thiabendazole
Chemical name: 2-(4'-Thiazolyl)benzimidazole
Trade name(s): Arbotect, Mertect, TBZ, Apl-Luster, Bioguard, Bovizole, Eprofil, Equizole, Lombristop, Mertect 160, Metasol TK 100, Mintesol, Mycozol, MK 360, Nemapan, Omnizole, Polival, Tebuzate, Tecto, Thibenzole 200, Thiprazole, Top form wormer, and Agrosol.
Structure:



CAS No.: 148-79-8
Formulations: Wettable powder, flowable concentrate, dust

2. PHYSICAL/CHEMICAL PROPERTIES:

Molecular formula: $C_{10}H_7N_3S$
Molecular weight: 201.1
Physical state: Colorless powder
Melting point: 304-305 °C
Vapor pressure: 4×10^{-9} mm Hg
Solubility (@ 25 °C): 10 mg/L water (pH 2);
<50 mg/L water (pH 5-12);
>50 g/L water (pH 12);
4.2 g/L acetone;
7.9 g/L ethanol;
2.1 g/L ethyl acetate.
Solubility (@ "room temperature"):
230 mg/L benzene;
80 mg/L chloroform;
39 g/L dimethylformamide;
80 g/L dimethyl sulfoxide;
9.3 g/L methanol.

B. **EXPOSURE CHARACTERIZATION**

1. ENVIRONMENTAL FATE ASSESSMENT

i. **Overview**

Thiabendazole photodegrades in water, but is quite stable to photolysis in soil and to hydrolysis. It does not metabolize significantly in soils, under aerobic and anaerobic conditions. Although it is shown to be quite persistent in the environment, EFED believes that thiabendazole will strongly bind to soil due to its high soil/water partitioning coefficients (K_{ads} = 2.76 mL/g in sand, 15.97

mL/g in sandy loam, 21.75 mL/g in silt loam, and 269.6 mL/g in clay), thus limiting the amount available for leaching into ground water and for runoff into surface water.

Three degradates were identified in the aqueous photolysis study (benzimidazole-2-carboxamide as a major degradate; benzimidazole and benzimidazole-2-carboxylic acid as minor degradates), two minor degradates in the aerobic soil (benzimidazole and 5-hydroxythiabendazole) and one major degradate in the anaerobic soil metabolism (benzimidazole) (see below). The only degradate that was analyzed for in the terrestrial dissipation studies is benzimidazole, since it is a major metabolite in a soil study (anaerobic soil metabolism). Test results showed that benzimidazole was not detected in any soil layers. No data were available for the other three degradates to verify their presence in the field. However, since they comprised a relatively small fraction (less than 10%) of the total applied radioactivity in the laboratory studies, EFED believes that their concentrations in the fields will also be at a non appreciable extent.

Thiabendazole degradates

Degradates	***Hydrolysis***	***Photolysis (water)***	***Photolysis (soil)***	***Aerobic Soil***	***Anaerobic Soil***	***Terrestrial Field***
Benzimidazole		X		X	X [1]	
5-hydroxy thiabendazole				X		
Benzimidazole-2-carboxamide		X [1]				
Benzimidazole-2-carboxylic acid		X				
Unidentified [^{14}C]		X		X		
Unknown 1				X		
$^{14}CO_2$				X		

[1] - major degradates

The following sections are summaries of the environmental fate studies. A detailed discussion of each study is included in Appendix I.

ii. Degradation and Metabolism

Hydrolysis (Guideline Reference Number 161-1): Thiabendazole is quite stable to hydrolysis. No major degradates were observed, with long half-lives ($t_{1/2} \geq 203$ days) for the parent compound in all of the aqueous buffered solutions (pH 5, 7, and 9). After 30 days (last test interval), at pH 5, thiabendazole parent was present at 85.4% of total applied; in pH 7 (HEPES), 91%; in pH 7 (TRIS), 100.5%; and in pH 9, 87.8%.

Photolysis in Water (161-2): Thiabendazole, in aqueous pH 5 buffer solution exposed to xenon lamp for 96 hours at 25°C, undergoes rapid photolytic degradation, with a half life of approximately 29 hours. Photodegradation involves primarily the structural alteration of the thiazole ring. Three degradates were identified: benzimidazole-2-carboxamide (average 10.22% of total radioactive applied), benzimidazole (average 6.49%); and benzimidazole-2-carboxylic acid

and at least one unidentified [^{14}C] residue (average 9.98%). The dark control samples show no degradation.

Photolysis on Soil (161-3): Thiabendazole is stable to photolysis on soil. No degradate was observed. The non-irradiated soil samples also show no degradation.

Aerobic Soil Metabolism (162-1): Thiabendazole degrades very slowly under aerobic conditions. In sandy loam soil that was incubated in darkness at 25°C and 75% moisture capacity for 12 months, thiabendazole half life was 668 days. After 12 months of incubation, 56.8% of the total applied radioactive remained as parent. Four metabolites were observed; two were identified (benzimidazole and 5-hydroxythiabendazole) and two were reported as unknowns:

- benzimidazole was seen immediately on day 1 at 2.2 % of total applied radioactivity, and decreased to 0.17% at the termination of the study (12 months), with no clear pattern of degradation.
- 5-hydroxythiabendazole did not exceed 0.33% of total applied radioactivity throughout the study.
- Unknown 1 was at 0.95% of total applied radioactivity immediately after treatment, reached a maximum of 12.3% on day 7 and decreased to 0.86% at the termination of the study. No discernable pattern of degradation was noted.
- another unidentifiable unknown (unknown 2) was seen, but at a non-significant concentration (maximum 0.32%).

Anaerobic Soil Metabolism (162-2 / 162-3): Thiabendazole undergoes slow microbial degradation under aerobic conditions, but is quite resistant to metabolism under anaerobic conditions. Parent thiabendazole was 88.3% of total applied radioactivity immediately after treatment, 74.0% at day 30, and 78% at day 90. At the end of 90-day study, cumulative volatiles amounted to 0.82% of the applied, and the non-extractable ^{14}C residues were at 5.5%. The only degradation product identified was benzimidazole, which was at a maximum of 13.7 % of the applied and decreased to 5.4% at study termination.

iii. Mobility

Leaching - Adsorption/Desorption(163-1): Based on the Organic Carbon normalized Freundlich values and the McCall's Mobility Classification Scale, thiabendazole appears to have some mobility in sand (K_{oc} =1104 mg/L), silt loam (K_{oc} =1813 mg/L), and sandy loam (K_{oc} = 3993 mg/L), but shows no mobility in clay (K_{oc} =22470 mg/L). The Freundlich adsorption coefficients (K_d's) are 2.76 mL/g in sand (0.25 %OC), 15.97 mL/g in sandy loam (1.2 %OC), 21.75 mL/g in silt loam (1.2 %OC), and 269.6 mL/g in clay (1.2 %OC). The desorption coefficients are 8.15 mL/g in sand, 19.46 mg/L in sandy loam, 16.03 mg/L in silt loam ,and 219.9 mL/g in 36 clay. No degradate was observed.

iv. Field Dissipation

Terrestrial Field Dissipation (164-1 & 164-5): Thiabendazole appears to be extremely persistent in the environment. The extrapolated half-lives ranged from 833-1100 days in cropped plots and

from 1093-1444 days in bare-ground plots. There were some trace levels of parent thiabendazole (up to 0.033 ppm; detection limit 0.01 ppm) in the 6-12 inch soil depth in the study conducted on loamy sand soil cropped with wheat (Washington) and on sandy loam soil with studies in Illinois. These detections could have been either sampling drag or legitimate leaching, given the elapsed time since application. This lack of active leaching in the field is quite consistent with the lack of soil mobility in the laboratory. The main degradate, benzimidazole, was not found in any of the sites. This is also consistent with the aerobic soil metabolism study, where benzimidazole did not exceed 2.2 % of applied thiabendazole.

Aquatic Field Dissipation (164-2) - waived.

Foliar Dissipation - waived.

Bioaccumulation - (165-4) - waived

2. TERRESTRIAL EXPOSURE ASSESSMENT

Birds and mammals can be exposed to pesticides applied as foliar sprays or granulars by a variety of routes, including ingestion, dermal contact, and inhalation. For thiabendazole, which is applied indoor as a seed treatment for wheat, exposure to wildlife is not relevant until treated seeds are planted back in the fields. Then, ingestion might become the route of exposure, as seed-eating birds and small granivorous mammals uncover and consume the treated seeds. It is uncertain how deep the seeds will be incorporated into the ground, however, if the seeds were planted deep into the ground, threat to wildlife would be insignificant. Applications and treatment of mushrooms are also for indoor uses, and therefore should be of minimal danger to birds and mammals. Exposure of terrestrial wildlife from direct injection of thiabendazole and its salt into trees may occur but is also expected to be a minimal means of exposure.

3. WATER RESOURCE ASSESSMENT

As in the assessment of terrestrial exposure, thiabendazole should be of minimal threat to drinking water resources, as most re-registered uses are for indoor where leaching into ground water and runoff to surface water are not likely to occur. But after the treated seeds are planted back in the fields, some water contamination concern may arise. However in that case, EFED also predicts that the high sorption affinities of this chemical will prevent it from being fully extracted from the seed coats onto the soils, thus reducing the amount available for leaching and run off. Furthermore, any thiabendazole desorbed from the seeds, will be strongly bound to soil (again due to its high soil/water partitioning coefficients), and should not be readily available for leaching and runoff.

Only major degradates in soil studies (metabolism and photolysis) were required to be analyzed in the terrestrial field dissipation studies to test their presence and persistence in the environment. Benzimidazole (major degradate of anaerobic soil metabolism study) was analyzed in the field, but not detected. No field data was available for benzimidazole-2-carboxamide and benzimidazole-2-carboxylic acid since they are degradates of the aqueous photolysis study. However, since these

two degradates comprised a relatively small fraction of the total applied radioactivity in the laboratory studies, EFED believes that if present in the fields, their concentrations will be insignificant to pose any major concern to the drinking water resource.

i. Surface Water Assessment

Based on the fate properties, if available in the filed after planting, thiabendazole should not dissolve, but will predominantly move off-site on entrained sediments into surface water. When it reaches surface water, thiabendazole is not expected to persist, especially in shallow and clear water, as this chemical is quite susceptible to direct photolysis ($t_{1/2}$ = 29 hours). GENEEC estimates a peak concentration of 2.4 ppb and an average 56 day concentration of 1.6 ppb (appendix II). These results were based on seeds treated with a maximum application rate of 3.6 oz ai/100 lbs, and 90 lbs of seeds planted per one acre. Note that when estimating using the typical application rate (0.25 oz ai/100 lbs or 0.01 lb ai/A), GENEEC reports a much lower peak EEC (less than 0.2 ppb).

ii. Ground Water Assessment

The extremely high soil-water partitioning coefficients K_d values of thiabendazole tend to reduce the potential for this chemical to leach through soils and contaminate ground water. This was confirmed in the terrestrial field studies, where no residues of this fungicide were detected in the layers deeper than 12 inches. The SCI-GROW model also reports less than 0.01 ppb of thiabendazole residues in ground water (appendix III), based on a maximum application rate of 3.6 oz ai/100 lbs.

4. AQUATIC EXPOSURE ASSESSMENT

For a Tier 1 assessment, EFED uses the GENEEC model. Note that seeds were treated indoor during storage, than later planted in the fields. The drinking water assessment is based on the use the treated seeds in the fields, as no runoff is expected from indoor treatment, except for possible runoff into the drainage system following the cleaning of the storage facility floor. However, this should have no impact on our drinking water assessment.

According to appendix II, the GENEEC program uses basic environmental fate values and pesticide label information to estimate the EECs in a one-hectare, two-meter deep pond following the planting of the treated seeds in a 10 ha field. The runoff event occurs two days after planting. GENEEC takes into account adsorption to the soil or sediment, degradation in soil before runoff, and degradation within the water body, then reports estimated concentrations of thiabendazole in surface water. It is not certain on how deep the seeds will be incorporated into the ground at planting. However, for this use, GENEEC assumes no seed incorporation and a maximum seed treatment rate of 3.6 oz ai/100lbs (or 0.203 lb ai/A) to derive a conservative estimation. The EECs presented below also assume that thiabendazole is fully dissociated from the coats of the treated seeds after planting (which is unlikely, based on the high K_{oc} values), and that there is no spray drift.

Estimated Environmental Concentrations (EECs) For Aquatic Exposure Using GENEEC.

Site	*Application Rate (lbs ai/A)*	*# of Apps*	*Initial (PEAK) (ppb)*	*21-day AVE (ppb)*	*56-day AVE (ppb)*
Wheat Seeds	0.203	1	2.37	1.96	1.55

5. DRINKING WATER EXPOSURE

For this reregistration, thiabendazole use on mushrooms should not cause any drinking water contamination, since treatment is performed indoor, and leaching into ground water and runoff to surface water are unlikely to occur. Treatment to wheat seeds is also indoor, but drinking water concern may arise since the treated seeds are later planted in the field. The following assessment is pertained only to the use of treated seeds planted in the fields.

For fairly new chemicals such as thiabendazole, for which there is no surface and ground water monitoring data, EFED generally recommends that the EECs generated from SCI-GROW (for groundwater sources) and GENEEC (for surface water sources) models be used for the drinking water risk assessment.

As discussed in the above section (Aquatic Exposure Assessment), the surface water GENEEC acute (peak) and chronic (56 day) values are in the proximity of 2 ppb. These values represent the upper-bound estimates of the concentrations that might be found in surface water due to the use of thiabendazole, and therefore can be used in screening calculations. If the level of concern is exceeded (which is unlikely in this case), it may be necessary to refine the GENEEC estimates.

For ground water, SCI-GROW reports 0.01 ppb for thiabendazole residues, based on the maximum application rate. This is expected as thiabendazole does not seem to significantly leach into ground water, due to its high soil/water partitioning coefficients. Terrestrial field study results also confirm the low leaching potential of this chemical in the fields, as thiabendazole was not detected in any of the soil samples below the 12" layer.

No fate data was available for the drinking water assessment of thiabendazole degradates. However, considering their limited presence in the laboratory and field studies, these degradates are not expected to be present in the field at any concentration which could cause any harm to the drinking water resources.

Overall, EFED believes that, thiabendazole use on mushroom and wheat will not present any significant contamination to either surface or ground water resources.

C. **ECOLOGICAL EFFECTS CHARACTERIZATION**

1. TOXICITY TO TERRESTRIAL ANIMALS

i. Birds, Acute and Subacute

An acute oral toxicity study using the technical grade of the active ingredient (TGAI) is required to establish the toxicity of thiabendazole to birds. The preferred test species is either the mallard or northern bobwhite. Results of this test are tabulated below.

Avian Acute Oral Toxicity

Species	***% ai***	***LD_{50} (mg/kg)***	***Toxicity Category***	***MRID No. (Author/Year)***	***Study Classification***
Northern bobwhite *(Colinus virginianus)*	99.6	>2250	practically nontoxic	410250-02 (Grimes and Jaber 1988)	core
Northern bobwhite	98	>4640	practically nontoxic	232421 (1977)	supplemental
Northern bobwhite	26	>4640	practically nontoxic	232421 (1977)	supplemental
Mallard *(Anas platyrhynchos)*	98	>4640	practically nontoxic	232421 (1977)	supplemental

The LD_{50}s exceed 2000 mg/kg, which categorizes thiabendazole as practically nontoxic to birds on an acute oral basis. The guideline (71-1) is fulfilled.

Two subacute dietary studies using the TGAI are required to establish the toxicity of thiabendazole to birds. The preferred test species are mallard and northern bobwhite. Results of these tests are tabulated below.

Avian Subacute Dietary Toxicity

Species	***% ai***	***LC_{50} (ppm)***	***Toxicity Category***	***MRID No. (Author/Year)***	***Study Classification***
Northern bobwhite *(Colinus virginianus)*	99.6	>5620	practically nontoxic	410250-03 (Grimes and Jaber, 1989)	core
Northern bobwhite	98	>10,000	practically nontoxic	232421 (1977)	core
Northern bobwhite	tech.	>14,500	practically nontoxic	ESVII (1968)	supplemental
Northern bobwhite	26	6849	practically nontoxic	232421 (1977)	supplemental
Mallard *(Anas platyrhynchos)*	99.6	>5620	practically nontoxic	410250-04 (Grimes and Jaber, 1989)	core

Because the LC_{50} values exceed 5000 ppm, thiabendazole is categorized as practically nontoxic to birds on a subacute dietary basis. The guideline (71-2) is fulfilled.

ii. Birds, Chronic

Avian reproduction tests are currently being required for all pesticides having outdoor uses. The preferred test species are the northern bobwhite and mallard. Test results for thiabendazole are tabulated below.

Avian Reproduction

Species	*% ai*	*NOEC/LOEC (ppm)*	*Affected Endpoints*	*MRID No. (Author/Year)*	*Study Classification*
Northern bobwhite *(Colinus virginianus)*	98.5	NOEC = 400 LOEC >400	none	235974 (Fink 1978)	core
Mallard *(Anas platyrhynchos)*	98.5	NOEC = 400 LOEC >400	none	235974 (Fink 1978)	core

Thiabendazole had no adverse effects on avian reproduction at dietary concentrations up to 400 ppm, the highest concentration tested. The guideline (71-4) is fulfilled.

iii. Mammals, Acute

Wild mammal testing is required on a case-by-case basis, depending on the results of lower tier laboratory mammalian studies, intended use patterns, and pertinent environmental fate characteristics of the pesticide. Laboratory rat or mouse toxicity values obtained from the Agency's Health Effects Division usually substitute for wild mammal testing. The available data for thiabendazole are tabulated below.

Mammalian Acute Oral Toxicity

Species	*% ai*	*LD_{50} (mg/kg)*	*Toxicity Category*	*MRID No.*
Laboratory rat *(Rattus norvegicus)*	98.5	5070 (♂) 4734 (♀)	practically nontoxic	412582-01
Laboratory rat	98.5	3330 (♂)	practically nontoxic	100853
Laboratory mouse *(Mus musculus)*	98.5	3810 (♀)	practically nontoxic	100853
Rabbit	98.5	3850 (♂)	practically nontoxic	100853

Because the LD_{50} values exceed 2000 mg/kg, thiabendazole is considered practically nontoxic to small mammals on an acute oral basis.

2. TOXICITY TO FRESHWATER AQUATIC ANIMALS

i. Fish, Acute

Two freshwater fish toxicity studies using the TGAI are required to establish the toxicity of thiabendazole to fish. The preferred test species are rainbow trout (coldwater species) and bluegill sunfish (warm water species). Results of these tests are tabulated below.

Freshwater Fish Acute Toxicity

Species	*% ai*	*Test Conditions*	*96-h LC_{50} (ppm)*	*Toxicity Category*	*MRID No. (Author/Year)*	*Study Classification*
Rainbow trout *(Oncorhynchus mykiss)*	99.6	flow-through (measured)	0.56	highly toxic	410250-05 (Belinger and O'Boyle 1989)	core
Rainbow trout	98	static	1.8	moderately toxic	227331 (1978)	core
Rainbow trout	tech.	static	3.5	moderately toxic	ESVIIGI (1968)	core
Rainbow trout	30	static	3.8	moderately toxic	ESM-LSP-6 (1977)	supplemental
Bluegill sunfish *(Lepomis macrochirus)*	98.5	static (measured)	19	slightly toxic	424777-01 (Holmes et al. 1992)	core
Bluegill sunfish	99.6	flow-through (measured)	>6.8	not determined	410250-06 (Belinger and O'Boyle 1989)	supplemental
Bluegill sunfish	98	static	22	slightly toxic	227331 (1978)	core
Bluegill sunfish	tech.	static	14	slightly toxic	ESVIIGI (1968)	core
Bluegill sunfish	30	static	56.3	slightly toxic	ESVIIGI (1968)	core

Because the lowest LC_{50} (rainbow trout) is >0.1 but <1 ppm, thiabendazole is categorized as highly toxic to freshwater fish. The guideline (72-1) is fulfilled.

ii. Fish, Chronic

A freshwater fish early life-stage test using the TGAI is not required for indoor uses or for the seed treatment use of thiabendazole, but data were previously submitted and reviewed. The preferred test species is the rainbow trout. Results of chronic tests are tabulated below.

Freshwater Fish Early Life-Stage Toxicity

Species	*% ai*	*Test Conditions*	*NOEC/LOEC (ppm)*	*MATC (ppm)* [1]	*Endpoint Affected*	*MRID No. (Author/ Year)*	*Study Classification*
Fathead minnow *(Pimephales promelas)*	98.5	flow-through (measured)	NOEC = 0.11 LOEC = 0.23	0.16	wet weight	425089-01 (Holmes and Swigert 1992)	core
Rainbow trout *(Oncorhynchus mykiss)*	98.5	flow-through (measured)	NOEC = 0.012 LOEC = 0.029	0.018	embryo viability	Acc. # 247102 (Wilson 1982)	core

[1] Maximum Allowed Toxic Concentration, defined as geometric mean of the NOEC and LOEC

iii. Invertebrates, Acute

A test using the TGAI is required to establish the toxicity of thiabendazole to freshwater aquatic invertebrates. The preferred test species is *Daphnia magna*. The test results are tabulated below.

Freshwater Invertebrate Acute Toxicity

Species	*% ai*	*Test Conditions*	*48-h EC_{50} (ppm)*	*Toxicity Category*	*MRID No. (Author/Year)*	*Study Classification*
Water flea *(Daphnia magna)*	99.8	flow-through (measured)	0.85	highly toxic	417094-01 (Holmes et al. 1990)	core
Water flea	98	static	0.31	highly toxic	ESTBZ-2	core
Water flea	30	static	0.49	highly toxic	ESM-LSP-5 (1977)	supplemental
Water flea	26	static	2.6	moderately toxic	232421 (1977)	supplemental

Because the lowest EC_{50} is between 0.1 and 1 ppm, thiabendazole is categorized as highly toxic to aquatic invertebrates on an acute basis. The guideline (72-2) is fulfilled.

iv. Invertebrates, Chronic

A freshwater aquatic invertebrate life-cycle test using the TGAI is not required for the seed treatment use of thiabendazole, but data were previously submitted and reviewed. The preferred test species is *Daphnia magna*. Results of this test are tabulated below.

Freshwater Aquatic Invertebrate Life-Cycle Toxicity

Species	*% ai*	*Test Condition*	*21-day NOEC/LOEC (ppm)*	*MATC (ppm)* [1]	*Endpoint Affected*	*MRID No. (Author/Year)*	*Study Classification*
Water flea *(Daphnia magna)*	98	flow-through (measured)	NOEC = 0.042 LOEC = 0.087	0.060	survival; offspring production	246711 (Surprenant 1981)	core

[1] Maximum Allowed Toxic Concentration, defined as geometric mean of the NOEC and LOEC

3. TOXICITY TO ESTUARINE MARINE ANIMALS

i. Fish, Acute

Acute toxicity testing with estuarine/marine fish using the TGAI is not required for thiabendazole, because minimal exposure is expected due to the low aquatic EEC for the seed treatment. However, a study was previously submitted and reviewed to support other uses not being supported for reregistration. Results of that study are tabulated below.

Estuarine/Marine Fish Acute Toxicity

Species	*% ai.*	*Test Conditions*	*96-h LC_{50} (ppm)*	*Toxicity Category*	*MRID No. (Author/Year)*	*Study Classification*
Sheepshead minnow *(Cyprinodon variegatus)*	99.6	flow through (measured)	>10	not determined	411920-03 (Surprenant 1989)	supplemental

An LC_{50} could not be determined for the sheepshead minnow, because the limited solubility of thiabendazole in organic solvents and seawater precludes testing at concentrations greater than 10 ppm.

ii. Invertebrates, Acute

Acute toxicity testing with estuarine/marine invertebrates using the TGAI is not required for thiabendazole, because minimal exposure is expected due to the low aquatic EEC for the seed treatment. However, a studies were previously submitted and reviewed for uses not being supported for reregistration. Test results are tabulated below.

Estuarine/Marine Invertebrate Acute Toxicity

Species	*% ai.*	*Test Conditions*	*96-h EC_{50}/ LC_{50} (ppm)*	*Toxicity Category*	*MRID No. (Author/Year)*	*Study Classification*
Mysid shrimp *(Americamysis bahia)*	99.6	flow through (measured)	0.34	highly toxic	411920-02 (Surprenant 1989)	core
Pacific oyster (larvae) *(Crassostrea gigas)*	99.6	flow through (measured)	>10	not determined	411920-04 (Surprenant 1989)	supplemental

Because the LC_{50} for the mysid shrimp, the most sensitive species, is in the range of 0.1 to 1 ppm, thiabendazole is categorized as highly toxic to estuarine/marine invertebrates on an acute basis. An LC_{50} was not established for the oyster, because the limited solubility of thiabendazole in organic solvents and seawater precludes testing at concentrations greater than 10 ppm.

4. TOXICITY TO AQUATIC PLANTS

Aquatic plant testing is required for any fungicide that has outdoor non-residential terrestrial uses and that may move off-site by runoff (solubility >10 ppm in water) and/or by drift (aerial or irrigation) or that is applied directly to aquatic use sites (except residential). Because the

only outdoor use is as a seed treatment and minimal contamination of surface water is expected, aquatic plant data are not required.

D. **ECOLOGICAL RISK ASSESSMENT**

EFED compares risk quotients (RQs) to levels of concern (LOCs) to assess the potential for adverse acute and chronic effects to terrestrial and aquatic organisms. A presumption of risk occurs when an RQ equals or exceeds an LOC. The RQ is determined as follows:

RQ = EEC / toxicity value

LOCs address the following acute and chronic risk presumption categories:

High risk:	the potential for acute risk is high; regulatory action may be warranted to eliminate or reduce risk.
Restricted use:	the potential for acute risk is high but may be mitigated through restricted use classification.
Endangered species:	the potential for acute risk to endangered species is high; regulatory action may be warranted to eliminate or reduce risk.
Chronic risk:	the potential for chronic risk is high; regulatory action may be warranted to eliminate or reduce risk.

The ecotoxicity values used in determining the RQs are:

LC_{50}:	fish (acute) and birds (dietary)
LD_{50}:	birds (acute) and mammals (acute)
EC_{50}:	aquatic invertebrates (acute)
NOEC:	birds (chronic)
MATC or NOEC:	aquatic animals (chronic)

Risk presumptions, RQ formulas, and LOCs are tabulated below.

Risk Presumptions for Birds and Mammals

Risk Presumption	***RQ***	***LOC***
Acute High Risk	EEC[1]/LC_{50} or LD_{50}/sqft[2] or LD_{50}/day[3]	0.5
Acute Restricted Use	EEC/LC_{50} or LD_{50}/sqft or LD_{50}/day (or LD_{50} < 50 mg/kg)	0.2
Acute Endangered Species	EEC/LC_{50} or LD_{50}/sqft or LD_{50}/day	0.1
Chronic Risk	EEC/NOEC	1

[1] EEC = Estimated Environmental Concentration (ppm) on avian and mammalian food items
[2] mg toxicant/ft^2 ÷ [LD_{50} * bird wt (kg)]
[3] mg toxicant consumed/day ÷ [LD_{50} * bird wt (kg)]

Risk Presumptions for Aquatic Animals

Risk Presumption	*RQ*	*LOC*
Acute High Risk	EEC[1]/LC_{50} or EC_{50}	0.5
Acute Restricted Use	EEC/LC_{50} or EC_{50}	0.1
Acute Endangered Species	EEC/LC_{50} or EC_{50}	0.05
Chronic Risk	EEC/MATC or NOEC	1

[1] EEC = Estimated Environmental Concentration (ppm or ppb) in water

1. POTENTIAL RISKS TO TERRESTRIAL ANIMALS

i. Birds and Small Mammals, Acute and Chronic

Based on the acute toxicity data indicating that thiabendazole is practically nontoxic to birds (LD_{50} >2000 mg/kg, LC_{50}s >5000 ppm) and small mammals (LD_{50}s >2000 mg/kg), and because exposure is likely to be minimal due to a low application rate (0.2 lb ai/A), acute risk is not expected from the use of thiabendazole as a seed treatment for wheat.

Chronic risk is not expected. Chronic exposure should be minimal from a seed-treatment use, and the available avian reproduction data indicate that chronic toxicity is not likely from such a low application rate as that for the wheat seed treatment.

2. POTENTIAL RISKS TO AQUATIC ANIMALS

i. Freshwater Fish

Risk Quotients for Freshwater Fish (based on Rainbow Trout LC_{50} of 560 ppb and NOEC of 12 ppb)

Site	*Appl. Rate (lb ai/A)*	*Peak EEC (ppb)*	*56- day-avg. EEC (ppb)*	*Acute RQ (EEC/LC_{50})*	*Chronic RQ (EEC/MATC)*
Wheat (seed treatment)	0.2	2.4	1.6	0.004	0.13

No acute or chronic LOC is exceeded for freshwater fish from a maximum seed treatment application on wheat.

ii. Freshwater Invertebrates

Risk Quotients for Freshwater Invertebrates (based on Water Flea EC_{50} of 850 ppb and Chronic NOEC of 42 ppb)

Site	*Appl. Rate (lb ai/A)*	*Initial EEC (ppb)*	*21-day-avg. EEC (ppb)*	*Acute RQ (EEC/LC_{50})*	*Chronic RQ (EEC/NOEC)*
Wheat (seed treatment)	0.2	2.4	2.0	0.003	0.05

No acute or chronic LOC is exceeded for freshwater invertebrates from a maximum seed treatment application on wheat.

iii. Estuarine/Marine Fish

Acute Risk Quotient for Estuarine/Marine Fish (based on Sheepshead Minnow LC_{50} of >10,000 ppb)

Site	*Appl. Rate (lb ai/A)*	*Peak EEC (ppb)*	*Acute RQ (EEC/LC_{50})*
Wheat (seed treatment)	0.2	2.4	<0.001

The acute LOC is not exceeded for estuarine/marine fish from a maximum seed treatment application on wheat.

iv. Estuarine/Marine Invertebrates

Acute Risk Quotient for Estuarine/Marine Fish (based on Mysid LC_{50} of 340 ppb)

Site	*Appl. Rate (lb ai/A)*	*Peak EEC (ppb)*	*Acute RQ (EEC/LC_{50})*
Wheat (seed treatment)	0.2	2.4	0.007

The acute LOC is not exceeded for estuarine/marine invertebrates from a maximum seed treatment application on wheat.

v. Endangered Species

No endangered species LOC has been exceeded. Therefore, no presumption of risk is made for any endangered species from use of thiabendazole as a seed treatment on wheat at a maximum treatment of 0.2 lb ai/acre.

E. **RISK CHARACTERIZATION**

It appears that there is minimum potential risk from thiabendazole to terrestrial animals or aquatic animals from the use of this fungicide to control diseases in mushrooms and wheat. In addition, neither the parent thiabendazole, nor its degradates are expected to pose any major concern to drinking water resources.

Appendix I - Summary of Submitted Environmental Fate Studies - Subdivision N

Degradation Studies

161-1 Hydrolysis (MRID# 41265301)

This study provides acceptable data and satisfies the EPA Data Requirements for the hydrolysis of thiabendazole in pH 5, 7 and 9 buffered solutions at 25°C. No additional data is required.

The study was considered unacceptable on 2/20/90 since a good estimate of the initial concentration was not provided, and one-dimensional TCL methodology was the only employed analytical technique. However, the registrant submitted an aqueous photolysis study (MRID # 41265101, reviewed on 2/20/90) that used adequate HPLC methodology. HPLC was effective for differentiating the parent compound from the degradates in the irradiated samples, and did not detect any degradate in the dark control samples (pH 5). Therefore, the photolysis study confirms that thiabendazole does not hydrolyze in pH 5 buffered solution. And since thiabendazole also showed no degradation in pH 7 and 9 solutions, the data generated from this study are deemed acceptable and fulfill the requirement for the hydrolysis of thiabendazole in all pH solutions tested.

Phenyl ring-labeled [^{14}C]thiabendazole (radiochemical purity 98.1%), at a nominal concentration of 10 ppm, degraded with registrant-calculated half-lives greater than 200 days in sterile aqueous buffered solutions adjusted to pH 5, 7 and 9. These solutions were incubated in the dark at 25°C for 30 days. The calculated rate constants are as follows: pH 5 - 0.0019 days^{-1}, $t_{1/2}$ = 357.1 days; pH 7 (HEPES) - 0.0034 days^{-1}, $t_{1/2}$ = 203.0 days; pH 9 - 0.0026 days^{-1}, $t_{1/2}$ = 270.8 days. [^{14}C]thiabendazole was the only compound detected (using TLC with one solvent system) in the buffer solutions at all sampling intervals, and comprised 97.9 to 98.9% of the radio-activity recovered at 30 days posttreatment. Between 1 and 30 days posttreatment, the material balance ranged from 80.9 to 83.6% of the applied for the pH 5 solution, from 90.3 to 102.4% for the pH 7-HEPES solution, from 88.9 to 99.5% for the pH 7-TRIS solution, and from 86.7 to 95.6% for the pH 9 solution.

161-2 Photodegradation in Water (MRID# 43328305)

This study provides acceptable data and completely satisfies the EPA Data requirements for the photolysis of thiabendazole in pH 5 buffered solution at 25°C. No additional data is required.

Phenyl ring-labeled [U-^{14}C]thiabendazole [2-(thiazol-4-yl)-benzimidazole; radiochemical purity 98.4%], at 10 ug/mL, photodegraded with a registrant-calculated half-life of 29.0 hours in aqueous 0.1 M acetate buffer solutions (pH 5). The solutions were continuously irradiated for 96 hours at 22.5-23.2 C using a borosilicate-filtered xenon arc lamp. The xenon lamp had an emission spectrum and a measured intensity (310-740 nm; 0.466-23.1 x 10^{19} photons/cm^2 **!** day) that approximated that of natural sunlight at 40°N when the sun was at the equinox (0.618-19.9 x 10^{19} photons/cm^2 **!** day); the intensity of the light received by the samples was approximately half the intensity of the lamp. The photodegradation of thiabendazole involves primarily the structure alteration of the thiazole ring. Formation of at least seven degradates was observed, however only three were identified: one major, benzimidazole-2-carboxamide; and two minors, benzimidazole,

and benzimidazole-2-carboxylic acid. In contrast, [^{14}C]thiabendazole did not degrade in the dark controls.

In the irradiated samples, [^{14}C]thiabendazole averaged 96.8% of the applied immediately posttreatment, 51.2% at 24 hours, 37.3% at 36 hours, and 10.4% at 96 hours. Uncharacterized [^{14}C]residues in the sample tube extracts (i.e. [^{14}C]residues that had adsorbed to the sample tubes) were maximums of 9.02-11.5% of the applied at 36 and 48 hours posttreatment. At 96 hours posttreatment, benzimidazole-2-carboxamide averaged 10.22% of the applied, and benzimidazole averaged 6.49%; benzimidazole-2-carboxylic acid and at least one unidentified [^{14}C]compound totaled 9.98%; and additional unidentified [^{14}C]compounds or uncharacterized [^{14}C]residues totaled more than 17% in distinct HPLC regions. Material balances were 99.4-109% of the applied through 48 hours posttreatment and 94.6-98.5% at 72 and 96 hours.

In the dark controls, thiabendazole averaged 98.1-102% of the applied throughout the study. Material balances were 98.3-105% of the applied through 96 hours posttreatment, with no discernible pattern of loss.

161-3 Photodegradation on Soil (MRID# 41397301 & 41397302)

The study MRID# 41397301 in conjunction with the supplemental study MRID# 41397302 provide acceptable data and completely satisfy the EPA Data requirements for the photodegradation of thiabendazole on soil. No additional data is required.

Phenyl ring-labeled [^{14}C]thiabendazole (radiochemical purity 95.4%), at 48.5 ug/g, was very stable to photolysis on sandy loam soil which was irradiated with artificial light (xenon arc lamp) at 11-41°C for 30 days. No photodegradation products were observed, with approximately 91 to 99 % of the parent compound detected in the soil extracts throughout the study. In similar, the test compound was stable in the non-irradiated samples.

Material balances were 92.4 to 104.2% of the applied for the irradiated samples, with no discernable pattern, and ≥100% of the applied for the non-irradiated samples.

Metabolism Studies
162-1 Aerobic Soil Metabolism (MRID# 41791201, DER 2)

Study (MRID# 41791201) provides acceptable data and fully satisfies the requirements for the metabolism of thiabendazole in aerobic mineral soils. No additional data was required.

Thiabendazole at 1.05 ppmw degraded with a calculated half-life of 668 days in sandy loam soil that was incubated in darkness at 25 °C and 75% of moisture capacity for 12 months. In soil extracts that were stored for up to 6 months prior to analysis, [^{14}C]thiabendazole was 89.1% of the applied immediately posttreatment, 73.2% at 1 month, and 56.8% at 1 year. The degradates benzimidazole and 5-hydroxythiabendazole did not exceed 2.2 and 0.33 % of the applied,

respectively. Unknown 1 was 0.95% of the applied in the immediate posttreatment samples, 7.6% at 1 day, 12.3% (maximum) at 7 days, 7.5% at 14 days, 0.5-5.3% between 1 and 6 months with no discernable pattern, and 0.90% at 12 months. Another unknown (Unknown 2) was seen at 0.32% on day 1 and at 0.56% at 6 month. At 12 months posttreatment, 5.6 and 0.24% of the applied had been evolved as $^{14}CO_2$ and other [^{14}C]volatiles, respectively. Unextracted [^{14}C]residues were 1.2-6.3% of the applied at $\leq$1 month posttreatment and 13.9-20.2% at 2 through 12 months. Throughout the study, material balances were 91.5-101.7% of the applied with no discernable pattern of decline.

There were some storage stability discrepancies observed between the aerobic soil metabolism study and the terrestrial field dissipation studies in this review. The registrant claimed that "Unknown 1," formed at up to 12.3 % of the applied dose in the 6 months of cold storage of soil extracts in the aerobic soil metabolism study, was an artifact of the cold storage. However, it appears that "Unknown 1" was also a metabolite formed in aerobic soil at a lower rate in soil extracts stored frozen for only 14-16 days and soil samples stored for up to 17 months in cold storage. "Unknown 1" was not found in any of the below storage stability studies using field-spiked soil. Therefore, it appears that "Unknown 1" was an unstable intermediate to some unknown soil metabolite. EFED can still determine the fate of thiabendazole in the environment even though a rapidly-formed and degraded metabolite was present, based on the results of quality long-term terrestrial field dissipation studies.

162-2/162-3 Anaerobic Soil-Water Metabolism (MRID# 41559601)

This study provides acceptable data and completely satisfies the EPA Data Requirements for the anaerobic soil metabolism of thiabendazole. No additional data is required.

Phenyl ring-labeled [^{14}C]thiabendazole was relatively stable in sandy loam soil incubated in the dark at 25°C under anaerobic conditions (nitrogen and flooding) for 60 days following a 30-day aerobic incubation period under similar conditions. The calculated half-life is 211 days for aerobic aging. During anaerobic aging, [^{14}C]thiabendazole appeared to be stable. Parent thiabendazole was 88.3% of the applied immediately posttreatment, 74.0% at day 30, and 78.0% at day 90 (day 60 post-flooding). Benzimidazole, the only major degradate, was present at a maximum of 13.7% of the applied at day 1 posttreatment, decreased to 8.3% by day 30 posttreatment and 5.5% by day 90 (day 60 post-flooding). Non-extractable residues increased from 0.62 to 5.8% of the applied during the first 30 days posttreatment, and were 5.5 to 6.2% throughout the remainder (anaerobic portion) of the study. At day 90 posttreatment, cumulative volatiles accounted for 0.82% of the applied. Material balances were 95.3 - 102.9% of the applied.

162-4 Aerobic Aquatic Metabolism - This study was waived since the currently registered labels do not contain aquatic uses.

Mobility

163-1 Leaching - Adsorption/Desorption (MRID# 41170102)

This study provides acceptable data and completely satisfies the EPA Data Requirements for the soil adsorption/desorption with thiabendazole. No additional data is required.

Based on the batch equilibrium studies and the McCall's Mobility Classification Scale, [^{14}C]thiabendazole (radiochemical purity 98.1%), at 0.45, 0.90, 1.76, and 4.62 μg/mL, was determined to have low mobility in sand and silt loam, some mobility in sandy loam and no mobility in clay:calcium chloride solution slurries (1:10) that were equilibrated for 24 hours at 25 ± 1 °C. The Freundlich adsorption coefficients K_{ads} (and exponents n) values were 2.76 mL/g (n = 1.49) in sand, 15.97 mL/g (n = 1.15) in sandy loam, 21.75 mL/g (n = 1.25) in silt loam, and 269.6 mL/g (n = 1.24) in clay soils. The respective organic content normalized Freundlich absorption coefficients ($K_{oc\text{-}ads}$) were 1104, 3992, 1812 and 22467mL/g. The average adsorption of thiabendazole ranged from 12.7% in sand to 98.7% in clay. Note that the adsorption increased with increasing CEC and clay content.

Following desorption in pesticide-free calcium chloride solutions (1:10 soil solution ratio) for 24 hours, approximately 1-2% of the radioactivity adsorbed to the clay soil, 16-28% to the silt loam soil, 28-32% to the sandy loam soil, and 41-60% to the sand soil was desorbed. The average adsorption of thiabendazole ranged from 12.7% in sand to 98.7% in clay. The Freundlich desorption coefficients K_{des} (and exponents n) values were 8.15 mL/g (n = 0.709) in sand, 19.46 mL/g (n = 1.08) in sandy loam, 16.03 mL/g (n = 1.69) in silt loam, and 219.9 mL/g (n = 1.34) in clay soils. The respective organic content normalized Freundlich desorption coefficients ($K_{oc\text{-}des}$) were 3260, 4865, 1336 and 18325 mL/g. The material balance ranged from 90 to 107%.

No data was reported on benzimidazole, the major degradate of the anaerobic soil metabolism study.

163-2 Laboratory Volatility - This study was <u>waived</u> because thiabendazole has a low vapor pressure (8.2 x 10^{-13} mm Hg at 20 °C)

163-3 Field Volatility - This study was <u>waived</u> because thiabendazole has a low vapor pressure (8.2 x 10^{-13} mm Hg at 20 °C)

Dissipation Studies

164-1 & 5. Terrestrial Field Dissipation

The terrestrial field dissipation studies listed below partially satisfy the EPA Data Requirements for Registering Pesticides, by providing acceptable information on the dissipation of the flowable concentrate formulation of thiabendazole. For a complete fulfillment of the terrestrial field dissipation requirement, acceptable data may be required for each <u>additional</u> formulation type at two typical use sites.

Thiabendazole formulated as Mertect 340-F; 3.8 lb ai/gallon flowable concentrate, was applied to soybeans and bare-ground plots in Illinois and Georgia (total application of 0.96 lb ai/A), and to wheat in Washington (total application of 1.08 lb ai/A). These studies can be used to support the registration of the flowable concentrate formulation of thiabendazole at the above mentioned application rates.

Thiabendazole appears to be extremely persistent in the environment. The extrapolated half-lives ranged from 833-1100 days in cropped plots and from 1093-1444 days in bare-ground plots. There

were some low levels of parent thiabendazole in the 6-12 inch soil depth in the study conducted on loamy sand soil cropped with wheat (Washington) and on sandy loam soil with studies in Illinois. This lack of active leaching in the field is also consistent with the lack of soil mobility in the laboratory. The main degradate, benzimidazole, was not found in any of the sites. This is also consistent with the aerobic soil metabolism study, where benzimidazole did not exceed 2.2 % of applied thiabendazole.

Immediate soil recoveries of applied thiabendazole were unusually low because the chemical was applied directly to foliage that covered the soil well. No plant sampling was conducted to verify the application rates, but the soil concentrations in all three studies increased to levels that approximated the nominal application rates. The following paragraphs detail the studies.

- This study **(MRID# 43187201)** provides acceptable data for evaluating the mobility and degradation of thiabendazole under field conditions.

Thiabendazole dissipated with a calculated half-life of 1100 days (r = -0.90) from the upper 6 inches of loamy sand soil (0.23 % OC) of Washington. Mertect 3.8 lb ai/gallon flowable concentrate was applied to wheat at a rate of 0.72 lb ai/A during the initial application and 0.36 lb ai/A for the second application, with a 34-day pretreatment interval. These applications were made foliarly when the wheat was in the 2-3 tiller growth stage and when the flag leaf first emerged.

In the 0-6 inch soil depth, soil concentrations of thiabendazole ranged from 0.14-0.28 ppm following the first application and 0.11-0.48 ppm in the 406 days following the second application with no clear pattern of decline. Soil concentrations of thiabendazole decreased slightly from an average of 0.20 ppm at 674 days to 0.15 ppm at 945 days and 0.14 ppm at 1096 days after the second application.

In the 6-12 inch soil depth, thiabendazole residues were detected in only one replicate sample, at 0.016 ppm 7 days following the second application; at 0.020-0.024 ppm on day 795; again in one replicate at 0.026 ppm on day 945; and at 0.017-0.018 ppm on day 1096.

No residues of this parent compound were found at or above the 0.010 ppm LOQ in any samples taken from below the 6-12 inch layer.

The aerobic soil metabolism degradate, benzimidazole (1,3-benzodiazole), was not detected at or above the LOQ level (0.010 ppm) at any sampling interval or at any depth.

Rainfall and irrigation totaled 22 inches/year in this study, or about 8 % less than the 10-year average rainfall of 24 inches/year. Plant sampling was not conducted in the study.

- This study **(MRID# 43187202)** provides acceptable data for evaluating the mobility and degradation of thiabendazole under field conditions.

Thiabendazole dissipated with calculated half-lives of 990 days (r = -0.76) from the upper 6 inches of soybean plots, and 1444 days (r = -0.63) from those of the bare ground plots. Both plots were

located in Illinois, and the soils were considered sandy loam soil (0.93 % OC). Mertect 340-F; 3.8 lb ai/gallon flowable concentrate was applied to both plots at a rate of 0.96 lb ai/A in August 1989, when the soybeans were in the early pod-fill growth stage. The applications were made via broadcast with a High Boy sprayer.

In the 0-6-inch soil depth of the vegetated plot, thiabendazole concentrations were 0.08-0.12 ppm immediately posttreatment, 0.16-0.37 ppm between 7 and 215 days with no clear pattern of decline, and 0.11-0.23 ppm at 396 through 1116 days. In the 0- to 6-inch soil depth of the bare ground plot, thiabendazole was 0.30-0.41 ppm immediately posttreatment, 0.33-0.76 ppm between 7 and 56 days, 0.15-0.61 ppm between 215 and 935 days with no clear pattern of decline, and 0.19-0.29 ppm at 1026 days and 0.08-0.40 ppm at 1116 days.

In the 6-12 inch soil depth, thiabendazole residues were found immediately posttreatment in both the vegetated plots (0.021-0.033 ppm) and the bare ground plots (0.014-0.015 ppm), and also on day 588 in the vegetated plots (0.012-0.019 ppm), with no pattern of decline.

Thiabendazole was not detected (LOQ = 0.01 ppm) in any of the core samples below the 12-inch depth.

The degradate, benzimidazole, was not detected (LOQ = 0.01 ppm) at any sampling interval at any depth.

Rainfall and irrigation averaged 46 inches/year in the study, approximately 21 % more than the 10-year average rainfall of 38 inches/year.

- This study **(MRID# 43187203)** provides acceptable data for evaluating the mobility and degradation of thiabendazole under field conditions.

Thiabendazole dissipated with calculated half-lives of 833 days ® = -0.72) from the upper 6 inches of vegetated (soybeans) plots, and 1093 days (r = -0.90) from those of bare ground plots. Both plots were located in Georgia, and the soils were considered sandy loam soil (0.45 % OC). Mertect 340-F; 3.8 lb ai/gallon flowable concentrate was applied to both plots at a rate of 0.96 lb ai/A in August 1989, via broadcast with a tractor-mounted sprayer.

In the 0-6 inch soil depth of the vegetated plot, thiabendazole was $\leq$0.04 ppm immediately posttreatment, increased to 0.05-0.26 ppm at 84 through 182 days, averaged 0.06 ppm at 362 and 543 days, 0.12 ppm at 721 days, and 0.04-0.09 ppm at 906 through 1082 days. In the 0- to 6-inch soil depth of the bare ground plot, thiabendazole was 0.16-0.20 ppm immediately posttreatment, 0.07-0.26 ppm between 7 and 721 days with no clear pattern of decline, and 0.06-0.22 ppm at 906-1082 days.

Thiabendazole was not detected below the 6-inch soil depth in either plot.

The degradate, benzimidazole was not detected (LOQ = 0.01 ppm) at any sampling interval at any depth.

Rainfall and irrigation averaged 55 inches/year in the study, approximately 8 % more than the 10-year average rainfall of 51 inches/year.

Storage Stability of Field Soil Samples

Thiabendazole did not degrade in loamy sand and sandy loam soil in 1120-1219 days of incubation in polyethylene bottles at -20 °C. Thiabendazole averaged 86-106 % of the applied through 3 years of storage. The storage stability of the degradate benzimidazole (1,3-benzodiazole) was variable. In the loamy sand soil, benzimidazole degraded slowly, averaging 102% of the applied immediately posttreatment, 93% at 0.5 month, 90% at 1 month, 78-80% at 3 through 12 months, 72% at 18 months, and 54% at 3 years. However, benzimidazole ranged from 85-100 % in the two sandy loam soils from the field dissipation studies.

Appendix II - GENEEC (GENeric Expected Environmental Concentration)

The EFED GENEEC model (version 1.2) is a screening model (generic high runoff site) used to estimate pesticide concentrations in surface water for up to 56 days after one runoff event. It also provides an upper-bound concentration value. GENEEC is a single runoff event model, but accounts for spray drift from single or multiple applications. GENEEC represents a 10-hectare field immediately adjacent to a 1-hectare pond that is 2-meter deep with no outlet. Normally, the pond is set to receive a pesticide load from spray drift for each application plus loading from a single runoff event (two days after the last application). For this indoor use on wheat, spray drift was set to 0%. The runoff event transports a maximum of 10% of the pesticide remaining in the top 2.5-cm of soil. This amount can be reduced with increasing adsorption to soil to a minimum of 1%. The amount of pesticide remaining on the field in the top 2.5-cm of soil depends on the application rate, the number of applications, the interval between applications, the incorporation depth, and the degradation rate in the soil.

Input Parameter:

Parameter	*Range*	*Value Used*	*Source*
Solubility (water)	10 mg/L	10 mg/L	EFGWB One-Liner
Hydrolysis $t_{1/2}$	stable at pH 7	0 day	MRID 41265301
Aquatic Photolysis $t_{1/2}$	29 hours	2.42 days (assuming 12 hours of sunlight/day)	MRID 43328305
Aerobic Soil Metabolism $t_{1/2}$	688 days	688 days	MRID 41791201 (DER 2)
Aerobic Aquatic Metabolism $t_{1/2}$	stable	(0 day)	No data available
K_{ad}	2.76 to 269.6 mL/g	see K_{oc} values	MRID 41170102
K_{oc}	1104, 1812, 3992 and 22467 mL/g	2903 mL/g (median value)	MRID 41170102

EECs (ppb or μg/L) [1]

Crops	*Appl. Rate (lb ai/A)*	*No. of Appl.*	*Initial EEC (ppb)*	*21-day EEC (ppb)*	*56-60-day EEC (ppb)*
Wheat - Seed treatment	0.203 [2]	1	2.4	2.0	1.6
Wheat - Seed treatment	0.014 [3]	1	0.17	0.14	0.11

[1]- It is not certain on how deep the seeds will be incorporated into the ground at planting. However, GENEEC assumes no seed incorporating depth to derive at a most conservative estimation. Note that, runoff will be practically non existent if the depth is greater than one inch.

[2] - Maximum application rate of 3.6 oz ai/100lbs or 0.203 lb ai/A, based on 90 lbs of treated seeds planted per acre .

[3] - Typical application rate of 0.25 oz ai/100lbs or 0.014lb ai/A, based on 90 lbs of treated seeds planted per acre .

Appendix III - SCI-GROW (Screening Concentration In GROUNDWATER)

The SCI-GROW screening model developed in EFED is an empirical model, which is based upon actual groundwater monitoring data collected for the registration of a number of pesticides that serves as benchmarks for the model. The current version of SCI-GROW appears to provide conservative estimates of peak pesticide concentrations over a 90-day period in shallow, highly vulnerable ground water sites (i.e., sites with sandy soils and depth to ground water of 10 to 20 feet). There may be exceptional circumstances under which ground water concentrations could exceed SCI-GROW estimates, however these circumstances are rare, as SCI-GROW model is based on worst-case conditions. It should be also noted that, since there is relatively little temporal variation in ground water, SCI-GROW concentrations could be used as acute and chronic values.

Inputs parameters:

Parameter	*Range*	*Value Used*	*Source*
Aerobic Soil Metabolism $t_{1/2}$	688 days	688 days	MRID 41791201 (DER 2)
K_{ad}	2.76 to 269.6 mL/g	see K_{oc} values	MRID 41170102
K_{oc}	1104, 1812, 3992 and 22467 mL/g	2903 mL/g (median value)	MRID 41170102

Ground Water Concentrations (ppb or μg/L):

Crop	*Application Rate (lb. ai/A)* [1]	*No. of Applications*	*Ground Water Concentration (ppb)*
Wheat (maximum application rate)	0.203	1	0.01

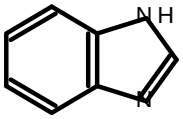
[1] - Maximum application rate of 3.6 oz ai/100lbs of seeds or 0.203 lb ai/A, based on 90 lbs of treated seeds planted per acre .

Appendix IV - References

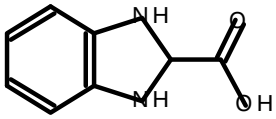
Fletcher, J.S., J.E. Nellessen, and T.G. Pfleeger. 1994. Literature review and evaluation of the EPA food-chain (Kenaga) nomogram, an instrument for estimating pesticide residues on plants. Environ. Toxicol. Chem. 13:1383-1391.

Hoerger, F. and E.E. Kenaga. 1972. Pesticide residues on plants: correlation of representative data as a basis for estimation of their magnitude in the environment. In F. Coulston and F. Korte (eds), Environmental Quality and Safety: Chemistry, Toxicology and Technology. Georg Thieme Publishers, Stuttgart, pp. 9-28.

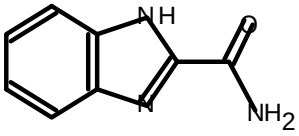
Appendix V- Structure and Nomenclature of Thiabendazole Metabolites



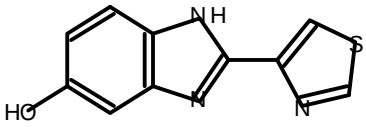
Benzimidazole



Benzimidazole-2-carboxylic acid



Benzimidazole-2-carboxamide



5-hydroxythiabendazole